EnergySmart Hospitals: Improving Design and Construction

Integrated Building Design and energy-efficient technologies maximize new hospital performance

Integrated Building Design (IBD) is a process that unites people, systems, business structures and practices from pre-design through operation and maintenance of a new building to achieve a more reliable, cost-effective, and energy-efficient facility. EnergySmart Hospitals has developed the following tips to help hospital owners, designers, and architects successfully use Integrated Building Design in constructing high-performance hospitals.

Pre-Design

During the pre-design phase, hospitals should identify project goals and needs; assess and confirm project feasibility and construction requirements; and assemble an experienced, proactive team of designers, architects, engineers, operators, and end-users.

Key steps that hospitals should follow include:

- Commit as an organization to the Integrated Building Design process for the project.
- Discuss and communicate concerns/questions around IBD concepts as a group.
- Formulate high-performance project goals, including measurable energy performance goals, financial evaluation criteria, and key project priorities.
  - » Example: Design building to use less than 100,000 Btu/square foot/year.
  - » Design building to have an ENERGY STAR® rating of 80.
  - » Design building to have 30 percent energy cost savings.

Integrated Building Design Team

Architects and designers
Construction managers
Contractors
Energy modelers, cost estimators
Engineers
Facility managers and operators
Integrated design facilitator/consultant
Medical staff (doctors, nurses)
Owners
Specialty consultants

- Assemble IBD team.
  - » Identify roles and responsibilities for members, including IBD "champion."
  - » Hire design professionals experienced with IBD.
  - » Hold full-design charrette with team members as kick-off for conceptual design.

Conceptual / Architectural

The most effective and least expensive way for a hospital to reduce energy demand is by planning the orientation of the new building and designing a building envelope with energy efficiency and cost savings as a clear goal.

- Maximize passive solar/natural light opportunities:
  - » Consider window layout and design to utilize as much natural light as possible, particularly in patient rooms and corridors.
  - » Natural light is most effective with a north/south exposure and when combined with control technologies.
  - » In addition to energy savings, natural light has been shown to speed patient recovery, and help employee productivity and alertness[1].
  - » Maximize shade provided by exterior landscaping (trees and shrubs) to minimize heat gain in warm climates.
  - » Perform preliminary modeling of building performance to address envelope and HVAC issues.
- Design the building with an energy-efficient envelope:
  - » Consider green roofs to provide insulation, lower intake temperatures, and improve patient views.
  - » Install revolving doors instead of standard doors in high-traffic locations to minimize loss of conditioned air.
  - » To ensure performance, contract for entire façade as a complete system.
- Investigate on-site renewable energy opportunities:
  - » Research available federal, state, and local incentives for on-site renewable energy.
  - » Facilitate available renewable energy opportunities through careful site selection.

> "Many high-performance 'green' buildings cost no more, and even less, than their 'brown' equivalents – the key is integrated design."
>
> *~ Robin Guenther*
> *Perkins + Will*

[1] "The Energy Efficient Hospital", by Michelle Halle Stern, *Sustainable Facility Magazine*, August 2008

Dell Children's Medical Center of Central Texas

Austin, Texas • Opened in July 2007

Design Architect:
Karlsberger • Columbus, Ohio

© John Durant Photography

The new 473,000 sq. ft. Dell Children's Medical Center of Central Texas, built on the "brownfield" site of a former municipal airport, serves 46 counties. The 169-bed hospital is the first inpatient hospital to achieve Leadership in Energy and Environmental Design, or LEED, certification at the platinum level, the highest offered through the U.S. Green Building Council.

- *$130 million construction cost*
- *$200 million capital budget*
- *32.2 acres of a 709-acre brownfield site*

Capital Infusion

- *Gross capital savings of $6.8 million from not building a Central Plant: cooling towers, chillers, emergency generators, and space*
- *Reinvested $5.8 million of these savings into building energy conservation measures and other LEED initiatives yielding intangible savings*

Combined Cooling/Heating Power Plant

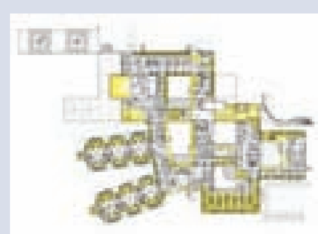
- 35,500 building gross square feet
- $18 million construction cost

CCHP Benefits

- *4.5MW natural gas-fired turbine supplies 100% of the hospital's electricity*
- *75% more efficient than coal-fired power plants*
- *Lower emissions of nitrogen oxides and carbon dioxide as a result of efficient combustion chamber technology*
- *Steam, a by-product of the conversion process, is utilized by the hospital in absorption chillers to produce all chilled water needs*
- *Enhanced quality of power assuring smooth, continuous operation of clinical equipment*
- *Two electrical feeds from different substations in the surrounding power grid provide 100% electrical redundancy*
- *Emergency generator provided for the CCHP black start-up provides a third backup for Life Safety Systems*

Notable Features:

- *"Right-sized" distributed air handling units with heat recovery system*
- *Under-floor air distribution where appropriate*
- *High-efficiency lighting fixtures with occupancy sensors*
- *External egress stairs where possible to reduce HVAC loads*
- *Low-flow and dual-flush plumbing fixtures save 1.4 million gallons of water per year*
- *Construction waste management (91% recycled – diverted 32,000 tons from landfills)*
- *Fly ash substituted for Portland cement in concrete mix*
- *100% of existing runway reused on site (47,000 tons)*



© John Durant Photography

First hospital to achieve a LEED point for Daylighting

Source: Karlsberger

- » Consider regional potential and effectiveness of on-site solar and wind power.
- » Check availability of geothermal and/or local landfills (methane) to maximize renewable energy resources.

- Consider merits of a building-integrated central plant vs. importing heating/cooling from off-site:
  - » Right-size boilers and chillers based on reduced loads from other improvements.
  - » Consider installation of modular heating and cooling system instead of redundant boilers and chillers; a modular system will operate more efficiently at or near its design capacity, reducing both maintenance costs and energy use.
  - » Use variable frequency drives (VFD) and system controls to maximize efficiency and avoid low $\triangle$T on chilled water system.

Design Development

Today's best practices and technologies can dramatically improve the energy performance of new hospitals, especially when utilized in the three building components that account for 60-80 percent of a hospital's energy use[2]: HVAC, lighting, and hot water. The following energy-efficient technologies and practices offer the best opportunities for savings.

- Lighting
  - » Install key energy-efficient lighting technology that offers the best opportunities for savings:
    - · Use light-emitting diodes (LEDs) in all exit signs.
    - · Install "super" T-8 lamps and high-efficiency electronic ballasts instead of standard T-8 lamps.
    - · Eliminate incandescent lamps where feasible.
    - · Install occupancy sensors in rooms that are frequently unoccupied.
    - · Maximize light-colored surfaces to encourage effective glare-free daylighting.

[2] "Energy Efficient Prescription for Health Care Facilities", by Rita Tatum, *Building Operating Management*, March 2008

  - » Incorporate daylighting controls in patient rooms and public spaces with large window areas; integrate controls with lamps and fixture types that can employ continuous dimming to lessen the apparent change.
  - » Specify and provide multiple levels of light—both general ambient and task lighting—in patient and exam rooms.
  - » In patient rooms, bright lights focused on patients can be turned on during examinations but remain off the rest of the time; multiple levels also allow for "downtime" lighting to allow patients to rest while lowering energy usage.
  - » Consolidate lamp inventories by eliminating unnecessary bulb types (different bulbs with same purpose).

- HVAC
  - » Install high-efficiency fans and air conditioning equipment to reduce energy usage in the HVAC system.
  - » Ensure HVAC systems operate with variable air volume (VAV) by using variable frequency drives (VFD) on all motors.
  - » Right-size fans, motors, and other HVAC equipment to take into account load reductions from energy-efficient technologies.
  - » Use air monitoring controls (spore traps and CO_2 sensors) to inform air-flow rates for demand-control ventilation.
  - » Utilize big, short, and straight pipes and smaller pumps to reduce energy needed to move air and water through the distribution system.
  - » Consider using combined heat and power (CHP) systems to supplement primary systems, help meet both heating and cooling loads, and add reliability to emergency operations.
  - » Investigate waste heat recovery opportunities.

- Hot Water, Medical Equipment, and Plug Loads
  - » Investigate use of heat exchangers to capture heat from hot wastewater and exhaust air.

© Peter Eckert

Providence Newberg Medical Center

Newberg, Oregon • Opened in 2006

Design Architect:
Mahlum Architects • Portland, Oregon

Providence's 180,000 sq. ft. hospital, medical office and administrative facility used an integrated design process, energy modeling, and life-cycle cost analysis of design alternatives to become the first hospital to achieve a LEED Gold rating. Energy-efficient lighting (T-5, daylighting controls), a high efficiency HVAC system providing 100% outside air, and a Variable Primary Flow chiller system helped Providence achieve 26% energy savings.

- *$63.5 million construction budget*
- *Incremental project cost: $357,000, financed partly through incentives from local utilities and Energy Trust of Oregon*
- *Energy savings: 26% reduced energy use over Oregon Energy Code*
- *Annual savings: $179,000*

Notable Features:

- *Condensing boilers operating at 95% efficiency (code standard: 80%)*
- *In exchange for $56,000 in incentives, hospital is leasing use of emergency generators to utility for maximum of 400 hrs/yr for 10 years*
- *High-efficiency lighting system emphasizes daylighting, for energy savings and enhanced environment*
- *Programmable lighting system monitors daylighting and dims or turns off lights when not needed*

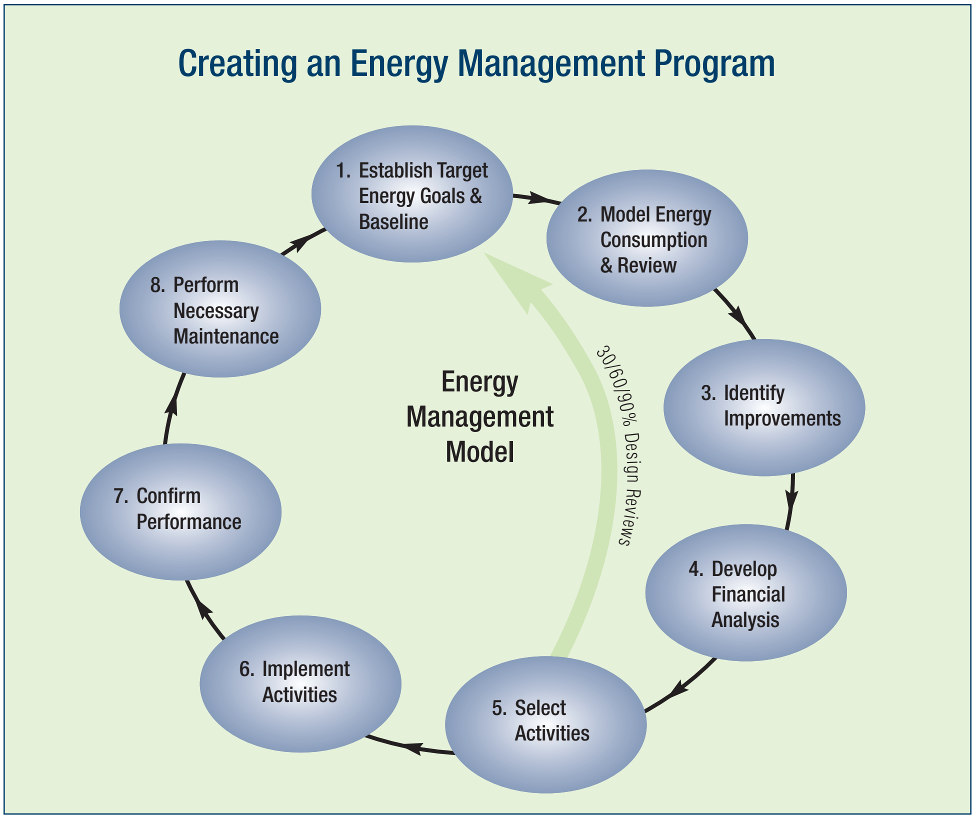
Source: Providence Newberg Medical Center

» Select ENERGY STAR-rated equipment and settings for all major office, kitchen, and other plug loads (computers, copiers, printers, dishwashers, vending machines).

» Incorporate set-back strategies into the design of Operating Rooms (ORs) and surgery suites:

- Keeping within code requirements, design ORs for reduced air changes during non-use time.
- Use thermodynamic modeling to assess airflow, and consider cooling occupants locally to standard 55-65° rather than ultra-chilling entire rooms.
- Choose effective locations for exhaust vents to improve infection control.

» Utilize energy-efficient equipment as much as possible, with stand-by modes, for major diagnostic equipment (MRIs, linear accelerators) that typically consume large quantities of energy.



Construction and Operations

During construction, ensure that contractors and subcontractors stay involved in the IBD process. Review all substitution requests carefully to determine what impact they'll have on energy performance goals and the energy efficiency of other building systems. Allow time for commissioning by an independent provider to complete functional testing.

Once construction is completed and occupancy of the new building begins, emphasis will shift from the Integrated Building Design Team to a new key group: the Energy Management Program Team. This group, reflecting wide representation from across the hospital (finance, maintenance and facilities, purchasing, quality assurance, government relations, clinical operations, medical personnel), will be charged with primary responsibility for the long-term success of all energy-efficiency planning and operations.

As the chart above illustrates, this team's responsibility will be the development and implementation of each element of the hospital's ongoing energy management plan. They will determine target energy goals, monitor performance, identify improvements, and oversee energy-efficiency O&M training and periodic recommissioning.

Over time, as the Energy Management Program Team verifies that all high performance goals are being met, they will also assess occupant satisfaction and fine-tune the integration of every aspect of energy efficiency. Programs such as EPA's ENERGY STAR for Healthcare can help develop energy management guidelines and benchmarking tools. Moving forward, the team will share feedback to identify approaches and solutions that continue to address challenges and target new opportunities for peak energy- and cost-savings.

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

For more information, contact:

www.eere.energy.gov/buildings/energysmarthospitals

U.S. DEPARTMENT OF ENERGY

Printed with soy ink on recycled paper

February 2009